Final Report
Book Cliff Survey for BLM Sensitive Bats
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Introduction

The Bureau of Land Management (BLM), Grand Junction Field Office (GJFO), manages approximately 1.2 million acres of public land in western Colorado. Pinyon-juniper woodlands are a common landcover in the area, and BLM regularly engages in habitat treatments in pinyon-juniper habitats to meet wildlife, range, or fuels objectives. Further, energy development in the area has increased dramatically in recent years.

Before any proposed action is approved (whether habitat improvement, fuels reduction, or energy development), analysis of potential impacts to natural resources, including wildlife, is required to comply with the National Environmental Policy Act. The level of detailed analysis possible in wildlife sections of NEPA documents that would address potential impacts to "Sensitive" wildlife species is often limited by a lack of data on subject species. All of the 5 BLM-Sensitive species listed for GJFO are bats, including big free-tailed bat (*Nyctinomops macrotis*), Yuma myotis (*Myotis yumanensis*), fringed myotis (*Myotis thysanodes*), spotted bat (*Euderma maculatum*), and Townsend's big-eared bat (*Corynorhinus townsendii*). All 5 may forage regularly or occasionally in pinyon-juniper habitats, and several that exhibit considerable plasticity in roost-site selection may roost in pinyon-juniper stands. Still, virtually no information exists on these species – or bats in general – in the Book Cliffs. Considerable survey effort for mine- and cave-roosting species (in coordination with the Colorado Division of Wildlife) has occurred in the southern portion of the GJFO (Gateway area, in particular) and within the Colorado National Monument. This survey complements those others and focuses on an area for which no information on bat species occurrence exists.

There have been several primary impediments to adequately assessing potential impacts to bats in local NEPA analyses for regularly proposed actions in pinyon-juniper habitats. Among them, the difficulties inherent to studying bat populations, the historic lack (though presently increasing) of interest in bat population status, and the absence of basic species occurrence information for the area. To address these information needs and improve future NEPA analysis, GJFO initiated a survey of the bat fauna of the Book Cliffs north of the Grand Valley in May and June 2006. GJFO contracted with the U.S. Forest Service, Rocky Mountain Research Station (Albuquerque, New Mexico) to conduct the survey.

The objectives of the survey were:
1. To record species composition of bats captured via mist-netting at water sources within or immediately adjacent to pinyon-juniper habitats of the Book Cliffs.
2. To evaluate (through radio-telemetry) whether bat species select roost sites in pinion-juniper stands, other vegetation, or in rock/cliff structures.

Methods

Net Site Identification

Potential net sites were identified during a scouting visit to the Book Cliffs with Brendan Moynahan (BLM-Grand Junction) and Lynae Rogers (BLM-Grand Junction) on May 11-12, 2006. We considered a site suitable for netting if it provided a relatively reliable and accessible source of water for bats, it occurred in or adjacent to pinyon-juniper habitat, and it was reasonably accessible by road. Net sites preferably contain water all summer long (or year-round), have large areas where the surface is not obstructed with vegetation, and are relatively shallow throughout (< 4 ft depth). A majority of efforts were focused on sites along West Salt Creek. Appendix A contains descriptions, directions, and photos of each net site.

Bat Capture Methods

We used bat capture methods outlined in Kunz and Kurta (1988) and operated under State of Colorado - Dept. of Natural Resources - Division of Wildlife - Scientific Collection License #06TR1094. Bats were captured in mist nets (6, 9, and 12m) set over pools of water. If pools were relatively deep, nets were placed across the corners and across areas of open water less than 4 ft deep. Nets were opened at dusk and were monitored constantly until they were closed when bat activity subsided (between 2300 to 0100). For each bat captured, species, sex, age, reproductive status, and time of capture were recorded. On nights when radiotransmitters were to be applied, a number of reproductive females were retained as candidates for radiotracking. Voucher specimens were deposited at University of New Mexico- Museum of Southwestern Biology.

Bat Roost Identification

Radiotelemetry is a method commonly used to identify structures used by bats as maternity roosts. Although relatively time consuming and expensive, radiotelemetry is a valuable method because it can lead to roosts that would not otherwise be found by targeted ground searches (i.e. checking buildings, caves, mines, etc.). To locate maternity roosts, we applied radiotransmitters to reproductive females and attempted to relocate them in their day roosts on subsequent days. The radiotransmitters weighed 0.25 g and were manufactured by Blackburn Transmitters (Nacogdoches, TX). Radiotransmitters were attached to the bat between the scapulae with surgical glue (Skin Bond ©). After the glue dried (approximately 30 minutes), the bats were released. Day- and night-time, ground-based radiotracking was conducted during the following 7 days to locate the radiotagged bats. Radiotransmitter batteries typically last 5-10 days, and signals typically travel from 1/4 mile to 2 miles, depending on terrain and type of roost (e.g. rocks vs. trees). On the second day after radiotagged bats were released, locations for the radiotagged females were determined by aerial telemetry with assistance from Colorado Division of Wildlife. Specific roost locations and structures were determined by ground-based telemetry. Once a roost was located, the roost structure was evaluated (roost type, location, characteristics), and GPS location was recorded. Whenever possible, we attempted to visually identify the bat and characterize its position within the roost.

Results

Bat Captures

My field crew and I conducted mist-netting at 9 sites over a two-week period from May 30 to June 11, 2006. Netting sessions lasted from 1.50 to 3.83 hours (average = 2.87 hours; SE=0.19 hours). We netted one location per night for the first nine nights, including a mix of streams and stock ponds. Most sites were netted only once due to limited time and resources. However, Mark Hill's 'North' stock tank along West Salt Creek was netted three times over the two week period due to the diversity and number of bats captured there. Mark Hill's 'North' and 'South' stock tanks were both netted on the tenth net night (June 11) because our intention was to capture up to 8 females suitable for the radiotracking portion of this study.

We captured from 2 to 45 bats per night, with the exception of June 3, 2006, when we caught none at Mitchell Desert Tank (Table 1). Although Mitchell Desert Tank appears to be a good net site, the night of June 3, 2006 was particularly windy and moon-lit, causing the nets to be more visible and reducing the likelihood of capturing bats. We did not return to that site due to limited time and because it did not occur in a priority habitat (e.g. was not pinyon-juniper). At stream sites (n=2), captures per night ranged from 2 to 20. At tank or pond sites (n=7), captures per night ranged from 14 to 45 (Table 1). Number of species captured per night was typically 5 to 6, but ranged from 2 to 10 (Table 1).

We captured a total of 237 bats of 12 species (Table 2). The silver-haired bat (*Lasionycteris noctivagans*) was the most commonly captured species. This species was captured on all nights when bats were captured and accounted for almost 50% of all captures (Table 2 and Table 3). Most captured individuals were male (98.2%; Table 3). The big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), and long-legged myotis (*Myotis volans*) were captured in similar numbers, collectively accounted for another 37% of total captures, and were captured at most net sites (Table 3). Most big brown and hoary bats captured were male whereas most long-legged myotis captured were females (Table 3). Remaining species were captured in low to very low numbers.

Radiotracking

On June 11, 2006, we netted at two stock tanks in close proximity (Mark Hill North and Mark Hill South) to capture bats for radiotelemetry. From the two tanks, we captured 5 species of *Myotis* (our target species) for radiotagging, including *M. californicus*, *M. ciliolabrum*, *M. evotis*, *M. thysanodes*, and *M. volans* (Table 4). The single male *M. thysanodes* was nonreproductive. The seven females were not discernibly pregnant.

Following radiotagging, some bats occasionally deviate from their typical roost patterns. Thus, we allowed one day to pass before tracking bats. On the morning of the second day following radiotagging (June 13, 2006), the principal investigator accompanied a pilot with the Colorado Division of Wildlife, who flew the area around the net sites, performed aerial telemetry, and obtained locations for each of the 8 radiotagged bats. From the afternoon of June 13 through June 18, 2006, we performed ground-based telemetry to locate and characterize roosts. Due to the time-consuming nature of ground-based telemetry and limited staff (three individuals), we could track only a few individuals per day. Thus we obtained our first locations on the first 4 bats

on June 13, on the fifth and sixth bats on June 14, and on the seventh bat on June 15 (Table 4). We did not attempt to locate the eighth bat, radio 093, until the fourth day because aerial telemetry had located this bat in a remote area that was time-consuming and difficult to reach by vehicle, difficult to traverse on foot, and distant from the other radiotagged bats. Thus, after spending one day searching for radio 093 (*M. ciliolabrum*) in the area identified through aerial telemetry, the principal investigator deemed efforts were better spent tracking daily movements of the other seven bats. The amount of time required to locate roosts is substantially reduced after the bat's first roost is identified because above-ground bat roosts are often clustered in a relatively small area. Thus, we were able to re-locate bats more easily and locate up to 5 bats per day in the latter half of the 7 day tracking period.

Movement among roosts

All radiotagged bats were located with aerial telemetry, and GPS locations were recorded from the air. Later the same day, we conducted ground-based telemetry and located four of the eight bats. Over the subsequent days (June 14-18), we located three of the four remaining bats and checked on locations of previously located bats.

Most bats (5 of 8) roosted within 1-2 km of the net site, and two bats roosted farther away (5-8km; Table 5; Figure 1). We located 2-3 unique roosts for each of the 7 bats. Bats typically remained in a roost 1-2 days before switching to a different roost, and we observed one bat return to a roost used 4 days prior (Table 4). The farthest distance between the roosts of a single bat ranged from 141m to 1000m (mean$\pm$SE; 423 $\pm$ 116m). Radiotagged bats were often visible and often appeared to be alone. Thus, most roosts were classified as solitary roosts. Only radio 206 (*M. volans*) was found roosting with a small number of other bats for one day.

Roost descriptions

Over a 7 day period, we located 18 roosts for 7 bats (Table 5). All five *Myotis* species were found in cliffs and boulders, which constituted 89% of the roosts located. In addition, one female *M. evotis* used two junipers in addition to a cliff roost (Table 5). Photos and brief descriptions of each roost are in Appendix B. On most photos, yellow arrows indicate specific roost location. Bats roosted under slabs, in cracks, or within eroded pits on boulders and cliffs. Boulders and cliffs were typically mid-slope, never in drainage bottoms or on ridge tops, and on relatively steep slopes (mean $\pm$ SE; 31.7 $\pm$ 1.9 degrees).

Discussion

Species captured in area were expected based on species-habitat associations and past records and reports. Although Yuma myotis were captured at Colorado National Monument (CNM; Adams 1990, Adams 1993, and Adams 1994), few, if any, Yuma myotis had been documented from the Book Cliffs. Thus, one female specimen was collected and donated to the Museum of Southwestern Biology (University of New Mexico) through the USGS field station associated with the department.

We captured three additional species (*L. cinereus*, *M. californicus*, and *M. evotis*) that were expected, but not documented during surveys of CNM from 1989-1994 (Adams 1990, Adams 1993, and Adams 1994). The large numbers of silver-haired and hoary bats were likely a result of these species passing through on their northward migration in the late spring and early summer. The large proportion of males captured is not surprising, given these species' tendency to segregate during the breeding season (Kunz 1982). Additional netting is necessary to determine whether males of these species remain in the area during the summer. The only species captured at CNM but not in this study was *M. lucifugus* (little brown bat).

Suitable roost habitat for the big free-tailed bat (rocky cliff faces) exists at both CNM and the Book Cliffs. At CNM, a big free-tailed bat was found on the ground and kept as a specimen (Adams 1994). Although we did not capture the big free-tailed bat, we heard vocalizations at net sites that may have been this species.

During summer months, Townsend's big-eared bats may roost in caves, mines, and buildings (Kunz and Martin 1982). This species was documented at CNM by 'triple-beam capture' photography (Adams 1994), and the Book Cliffs may also provide suitable habitat. However, we did not capture any Townsend's big-eared bat, most likely because this species is particularly agile in flight and adept at avoiding mist-nets. Thus, the probability for capture was low, given our very limited mist-netting efforts. Similar to the big free-tailed bat, the spotted bat roosts in high rocky cliffs and is adept at avoiding mist-nets. Although this species is likely present in the Book Cliffs, neither this study nor surveys at CNM documented this species (Adams 1994).

Given the extremely narrow window during which bats were sampled, the limited number of net sites, and the many variables that influence bat activity and capture success (e.g. season, moon, wind, water availability, net site characteristics, prey activity, etc.), this study's capture data should not be considered fully representative of the area, the summer season, or any particular site. Results should be interpreted with great care and in the most general sense (e.g. to understand species present in the area at this time of year and to infer some idea about relative abundance). The higher species diversity and abundance at the Mark Hill North and South tanks may have been due to the relatively persistent and large area of water in these tanks, the relative unavailability of open water in this section of the canyon, and adjacent roost habitat.

Most females captured were recorded as non-reproductive. However, in late spring and early summer, it is difficult to correctly identify pregnant females because undeveloped fetuses are difficult to manually palpate. At the time of year this study was conducted, females were likely to be in early stages of pregnancy, would have been difficult to identify as pregnant, and may

have been recorded as non-reproductive. All females for which we located roosts were recorded as non-reproductive.

We located roosts for two female long-eared myotis, two female long-legged myotis, one female small-footed myotis, one female California myotis, and one male fringed myotis. Roost-switching behaviors of the radiotagged myotis in this study were similar among species and similar to previous studies in New Mexico (Bogan et al. 1998, Chung-MacCoubrey 2003). Bats in this study switched roosts frequently (every 1-2 days), but generally remained in the same general area. Roosts of a single bat were typically less than 0.5km apart, and one bat was returned to a previously used roost during the 7-day period. The two long-eared myotis moved larger distances between roosts than the other species and fringed and long-legged myotis roosted farther from the release site than other species, but these differences are not statistically supported due to small sample sizes.

All five species used rocks as roosts, and one female long-eared myotis used two junipers in addition to a rock crevice. Rock crevice roosts were in boulders, under slabs, and in fissures and cracks of cliffs- all of which were typically on steep slopes and positioned mid-slope. Crevices appeared to be relatively shallow (< 3 ft), and bats were often observed close to openings (and thus were visible). The two tree roosts were large, mature junipers with a significant number of large dead limbs. The female long-eared myotis roosted in cracks and crevices of dead and live portions of these trees. Tree roosts such as these were commonly used by bats in pinyon-juniper woodlands of west-central New Mexico (Chung-MacCoubrey 2003). Junipers contain many crevices suitable as roosts because of their twisted and convoluted bark and wood (live and dead). We expected to find more tree roosts than observed due to the availability of large junipers throughout the study area and because long-legged, long-eared, fringed, and small-footed myotis predominantly roosted in trees in pinyon-juniper woodlands of west-central New Mexico (Chung-MacCoubrey 2003). However, long-legged, fringed, and long-eared myotis used rock crevices in the Jemez Mountains of New Mexico, despite the availability of trees in the surrounding pinyon-juniper and ponderosa pine habitats (Bogan et al. 1998).

Many factors affect roost selection, and bats exhibit considerable plasticity in the types of structures used as roosts. In this study, we cannot make conclusions about roost preferences for the radiotagged species due to the small number of bats tagged per species, limited number of roosts found, and narrow study window. However, it is clear that rock crevices are an important roost resource for several species of bats in the Book Cliffs during the early summer, that junipers are a potentially important, although poorly documented, roost resource, and that more extensive research is needed to investigate the roost preferences of these species in different reproductive stages, over longer periods than two-weeks, and over a wider study area.

Acknowledgments
Hearty thanks to Brendan Moynahan and folks at the BLM-GJFO for funding and supporting this study. Colorado Division of Wildlife contributed flight time and a pilot to this operation, which greatly improved our ability to locate bat roosts. Lastly, this project would not have been possible without the assistance of two excellent Student Conservation Association interns, Elizabeth Mering and Ben Martin, who remained enthusiastic and dedicated during the long and grueling hours of netting and radiotracking.

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Table 1. Numbers of species, bats, and minutes netted by site and date in the Book Cliffs (Mesa County, CO, 2006). In parenthesis by the site name is the cumulative number of bat species captured at that site.

Net site (# species)	Net Date	# hours	# captures	# species
Alkali Canyon (5)	06-Jun-06	3.43	45	5
Buniger Canyon Tank (5)	01-Jun-06	2.72	34	5
Carr Creek (4)	04-Jun-06	3.50	20	4
Corcoran Wash West (6)	10-Jun-06	3.00	19	6
East Salt Creek North (2)	02-Jun-06	2.10	2	2
Garvey Canyon Tank 2 (5)	31-May-06	2.38	17	5
Mark Hill North Tank (11)	30-May-06	3.72	34	8
	05-Jun-06	3.17	14	6
	11-Jun-06	2.67	17	6
Mark Hill South Tank (10)	11-Jun-06	3.83	35	10
Mitchell Desert Tank (0)	03-Jun-06	1.50	0	0
Total		37.28	237	12

Table 2. Number of each species captured by site in the Book Cliff study area (Mesa County, CO, 2006). Species abbreviations are listed below the table.

Site Name	ANPA	EPFU	LACI	LANO	MYCA	MYCI	MYEV	MYTH	MYVO	MYYU	PIHE	TABR	TOTAL
Alkali Canyon		9	2	31		2					1		45
Buniger Canyon Tank		4		27		1	1		1				34
Carr Creek		3	10	5					2				20
Corcoran Wash West		11		3		1	2		1		1		19
East Salt Creek North		1		1									2
Garvey Canyon Tank 2		1	2	11			1		2				17
Mark Hill North Tank	1	1	13	23	4	2	2		16	1	1	1	65
Mark Hill South Tank	1	4	1	12	4	3		1	3		5	1	35
Total	2	34	28	113	8	9	6	1	25	1	8	2	237

Species abbreviations:

ANPA = *A. pallidus*
EPFU = *E. fuscus*
LANO = *L. noctivagans*
LACI = *L. cinereus*
MYCA = *M. californicus*
MYCI = *M. ciliolabrum*
MYTH = *M. thysanodes*
MYVO = *M. volans*
MYYU = *M. yumanensis*
PIHE = *P. hesperus*
TABR = *T. brasiliensis*

Table 3. Total captures, proportion of females, and the number of sites and nights a species was captured in the Book Cliffs (Mesa County, CO, 2006). Species are in order by decreasing number of captures.

Bat species	# captures	# sites	# nights	% female
Lasionycteris noctivagans	113	8	9	1.8
Eptesicus fuscus	34	8	8	20.6
Lasiurus cinereus	28	5	6	7.4
Myotis volans	25	6	7	83.3
Myotis ciliolabrum	9	5	5	66.7
Myotis californicus	8	2	3	62.5
Pipistrellus hesperus	8	4	4	25.0
Myotis evotis	6	4	4	50.0
Antrozous pallidus	2	2	2	50.0
Tadarida brasiliensis	2	2	2	100.0
Myotis thysanodes	1	1	1	0
Myotis yumanensis	1	1	1	0

Table 4. Description of radiotagged bats, outcome of radiotracking efforts following radio application on 6/11/06, and maximum distance between roosts of one bat. Values in the table represent the roost ID in which the bat was located or indicate that no ground search was conducted (NS) or that no roost was located (US; 'unsuccessful search').

			Outcome of radio tracking in 2006							Max.
ID	Bat species	Sex	6/12	6/13	6/14	6/15	6/16	6/17	6/18	distance (m)
068	*M. ciliolabrum*	F	NS	0680613	0680613	NS	0680616	0680616	0680613	307
093	*M. ciliolabrum*	F	NS	NS	NS	US	NS	NS	NS	-
135	*M. californicus*	F	NS	1350613	1350614	NS	NS	1350617	NS	427
187	*M. thysanodes*	M	NS	NS	NS	1870615	NS	1870617	US	278
206	*M. volans*	F	NS	NS	2060614	2060615	2060615	2060617	NS	141
257	*M. volans*	F	NS	NS	2570614	NS	2570616	NS	NS	166
335	*M. evotis*	F	NS	3350613	NS	3350615	3350615	NS	3350618	1000
432	*M. evotis*	F	NS	4320613	NS	4320615	4320615	NS	4320618	646

Table 5. Characteristics of roosts used by radiotagged bats (*Myotis* spp.) in the Book Cliffs (Mesa County, CO) during early summer 2006. Roost ID indicates '(radio number) – (month& day located)'.

Species[a]	Roost ID	distance from release site (km)	Rock type	Elev-ation (ft)	slope position[b]	slope (deg)	slope aspect (deg)	Boulder or cliff height (ft)	crevice type	crevice direction	crevice depth	height of roost exit (in)	width of roost exit (ft)	aspect of roost exit (deg)	saw bat?
MYCI	068-0613	1.1	Boulder	5832	4	35	150	6	slab	horizontal	> 1ft	1	2.5		Yes
	068-0616	1.1	Boulder	5788	2	31	168	4	slab	horizontal	6 in	2	1	168	Yes
	093-0613	7.0	GPS location obtained from aerial telemetry on June 13, 2006. No roost ever located.												
MYCA	135-0613	1.0	Cliff	6012	2	38	130	15	unsure	unsure	unsure	unsure	unsure	130	No
	135-0614	1.3	Cliff	6175	3	34	120	40	unsure	unsure	unsure	unsure	unsure	145	No
	135-0617	1.0	Boulder	6023	2	34	183	6	slab	horizontal	3 ft	0.75	1	183	Yes
MYTH	187-0615	5.3	Cliff		2	43	71	25	wide fissure	vertical	> 6 in	unsure	unsure	71	No
	187-0617	5.5	Boulder	6399	2	40	200		crack	horizontal	> 4 ft	12	4	200	No
MYVO	206-0614	7.5	Cliff	6877	4	25			slab	horizontal	6 in	24	1.5		Yes
	206-0615	6.5	Cliff	6890	4	30	102	20	crack	vertical	3 ft	6	0.25	124	No
	206-0617	7.3	Boulder	6748	3	26	165	7	crack	vertical	1.5 ft	12	0.33	114	Yes
	257-0614	1.9	Cliff	6430	4	30	93	38	eroded pockets	circular	1-2 ft	12-36	1-3	93	No
	257-0616	1.7	Cliff	6210	2	15	110	22	Unsure	horizontal	> 3 in	3-4	1-3	110	No
MYEV	335-0613	1.4	Boulder	6727	3	29	142		shallow pit in rock face	shallow circular pit	4 in	24	2	142	Yes
	335-0615	1.0	Boulder	6065	2	20	240	10	slab	horizontal	9 in	2	2	60	Yes
	335-0618	1.3	Boulder	6598	3	41	144	5	slab	horizontal	5 in	1	0.5	120	Yes
	432-0613	1.3	Juniper	6823	*Juniperus osteosperma*. 4.27m tall. 61cm diameter at root crown. ¾ of tree is dead.										
	432-0615	1.4	Cliff	6243	3	36	340		crack	horizontal	6 in	3	2	340	Yes
	432-0618	1.1	Juniper	6628	*J. osteosperma*. 3.05m tall. 56cm diameter at root crown. ½ of tree is dead.										

[a] Species abbreviations: MYCA = *M. californicus*, MYCI = *M. ciliolabrum*, MYTH = *M. thysanodes*, MYVO = *M. volans*
[b] Slope position codes: 1= bottom of slope, 3= mid slope, 5= ridge

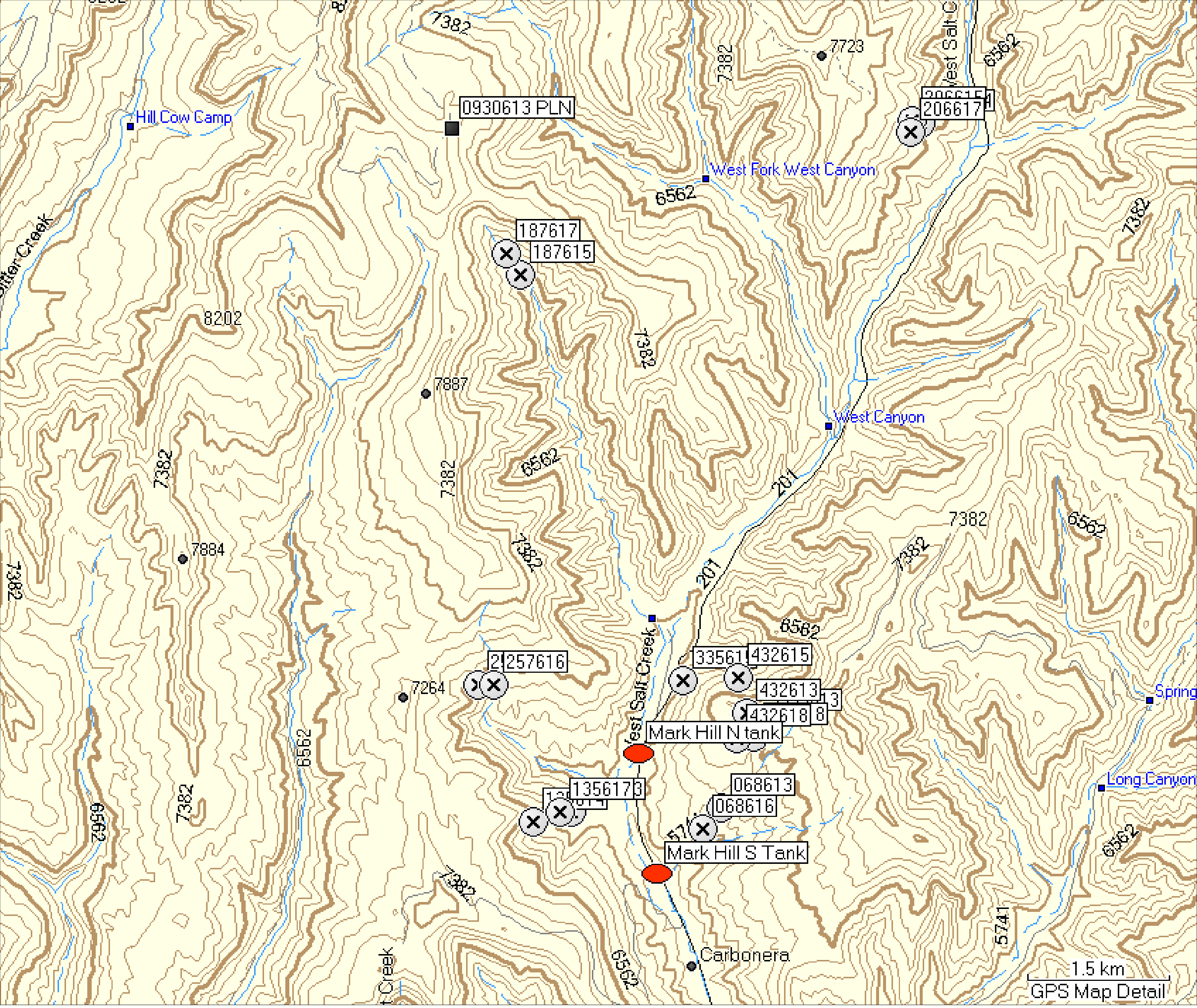

Figure 1. Roost locations relative to sites where bats were captured and radiotagged. See Appendix B for GPS coordinates. Roosts are represented by circles with central X's; net sites are represented by red ovals.